STATE & PRIVATE FORESTRY
FOREST HEALTH PROTECTION
SOUTH SIERRA SHARED SERVICE AREA

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Subject: **General Sherman Forest Health and Fuels Reduction Project, 2018**

Introduction

General Sherman Project evaluated roughly 12,340 acres on Placerville Ranger District, Eldorado National Forest primarily along the west side of Silver Fork Road connecting Highway 50 to Iron Mountain Trail. Past management and fire suppression policies have significantly altered stand conditions outside range of natural range of variability of Sierra Nevada forests. Current conditions in the project area are at risk for insect and disease infestation, or catastrophic wildfire. Forest composition has shifted dramatically to more shade-tolerant tree species in higher densities, while shade-intolerant species have been removed by damage agents with minimal regeneration in the understory. This project is intended to move current conditions closer to historical ranges, while achieving additional goals that provide safety and long-term viability. Project purpose and needs are detailed as follows (General Sherman Project proposal *draft*, December 2017):

- Create Resilient landscape conditions that reduce the threat of catastrophic wildfires to ecosystems and surrounding communities; reintroduce fire into fire-adapted ecosystems
- Need to restore forest structure and species composition to a condition that is more resilient to damaging agents, drought, wildfire, etc.
- Promote and enhance wildlife through enhancements of meadows and aspen groves, promotion of old-forest types, stream improvements, and protection of existing habitat structures from wildfire
- Improve hydrologic functioning of watersheds within portions of the Placerville District; need to maintain and improve watershed and soil conditions
- Design treatments to meet objectives that is efficient and effective for the next 20 years.

The recent drought event has been categorized as unprecedented and historic for associated widespread tree mortality, the minimal amounts of precipitation, and warmer temperatures than recorded in California (Robeson 2015). The resulting bark beetle-associated mortality is considered so severe many areas experienced >50% of overstory die-off categorizing them in a deforested state.

Observations

During a field trip in September 2017 with IDT team and project collaborators, three basic forest types/conditions were visited: mixed-conifer natural stands, young pine plantations, and red fir natural stands. Most of the project area is comprised of mixed-conifer forests transitioning to red-fir dominated forests (4600-7000 feet elevation). Stand exams show a very low percentage of ponderosa pines in larger (>10" DBH) diameter classes, compared to sugar, Jeffrey, and white firs which have above 40% of trees in this range. Red firs, incense cedars, and lodgepole pines are also noted.

Figure 1. Mixed conifer stand in General Sherman Project, Road XNXX

Larger red fir only comprising about 20% of red fir type stands, while white fir numbers are doubled all size classes compared to red fir. Natural mixed conifer stands visited in the project area were fair to overstocked, with a predominance of white fir and dense canopy cover (see figure 1). Understory brush was low to minimal and tree canopy height was high due to crown closure. A young Jeffrey pine plantation at the second stop was thick with deer brush and whitethorn manzanita in the understory, and tree crowns just beginning to touch. No mortality was noted here, and overall mortality at field stops was minimal except for moderate to larger diameter sugar pines.

Aerial detection surveys of 2016 and 2017 show dramatic increases in mortality since 2015, with over 50% of the project boundary affected to some degree with mortality both years (see Appendix A). Polygons detected in Placerville Ranger District within the project boundaries show bark beetles attacking large areas (100-3000 acre groups), some with tree loss in multiple species – up to 15 trees/acre. Polygons were rated at mostly moderate (11-20% affected) down to light (0-10% affected). Scattered white fir mortality was detected at variable elevations, variable aspects. Most of this fir mortality was noted in the understory or lower canopy which would be missed from the air. Mortality significantly increased in red firs from 2016 and 20117 – 6000 trees in 2016 to 510,000 in 2017 (FHM ADS 2017). Ponderosa pine mortality at this higher elevation has been much less, and did not appear significant as compared to other large groups (>100 trees/group) noted on the Amador or lower Placerville district. Bark beetle-associated mortality in Eldorado NF has been most severe at lower elevations (FHM ADS 2015-2016). Mortality is visible in mixed stands of pines and firs, but smaller groupings per acre were observed this year. Bark beetles have mostly concentrated in predominantly pine stands were basal areas were above 200, and average diameters were greater than 18 inches (FHP, *personal observation*).

Forest pathogens are not as obvious as insect infestations, but symptoms of diseases are apparent if one knows what to look for. Root disease often leave "gaps" in stands where infections radiate out from a central host(s), slowly killing trees as the infection spreads either from root-to-root contact or aerial spores. These gaps are more visible in stands where there is lots of host type and disease has been established for a number of years. Fir engraver-associated mortality is often cited as singular damage agents, overlooking the strong possibility of prior root disease infection. These centers are not easily discernable from aerial survey, so would not show up on annual mortality maps. Gaps were most obvious in mixed-conifer white fir forest type within General Sherman project, where older fir stumps were

found with *H. occidentale* conks half of the time (see Figures 2a and 2b). Several units were confirmed with presence of *H. occidentale*, while others showed symptoms of presence. No *Heterobasidion* signs or symptoms were found in the highest unit along Mormon Immigrant Trail. Dwarf mistletoe rating (DMR) in proposed red fir units were in the moderate range, with many small trees having latent or small plants in the canopy.

Figure 2a) White fir tree next to live stump found with Heterobasidion occidentale. Caples Creek Equestrian Trailhead, Pacific RD. 2b) H. occidentale conk.

Discussion on Proposed Management Alternatives regarding Forest Health

Native Insects and Pathogens

Native insects and pathogens have closely evolved with their associated hosts in North American forests. Their roles as natural disturbances at the micro and landscape scale significantly contribute to ecosystem functioning and productivity. While current wildfires in the West have been categorized as catastrophic and outside of historical fire conditions, similar things could be said about insects and diseases (Raffa et al 2008, Bentz et al. 2012, Anderegg et al 2015). Land use of the past century, evolving land management policies, and changing climate has influenced behavioral patterns of native damage agents creating positive feedback loops that benefit their growth or distribution (Raffa et al 2008). *Heterobasidion* root disease is more widespread and has intensified in Sierra Nevadas, particularly in fir dominated stands due to past practices (Potter 1998). Their responses to beneficial conditions often conflict with management objectives and goals, though not always negative. Snags and large coarse woody debris create wildlife habitat and biomass for soils, but the current magnitude of dead trees has also created hazardous conditions for public safety and catastrophic mass wildfire (Stephens et al. 2018). Fettig stated in GTR-237 (2012) that the status of current ecosystem resilience and resistance can be gauged by bark beetle responses. Bark beetles have destroyed over 102 million trees in the state by 2016, 1.6 million in Eldorado County alone (TMTF 2017). Northern California counties still experienced mortality toward the tail end of the drought, as tree stress can still linger due to prolonged canopy water loss (Asner et al. 2015), or critical biotic thresholds have been crossed that perpetuate insect population success (Bentz et al 2010).

Bark beetle prevention

The recent bark beetle epidemic appears to have subsided to some degree due to abundant precipitation of 2016-2017. Tree mortality was especially severe in southern Sierra forests, but Eldorado National Forest had increases in 2016 and

2018, particularly at higher elevations. This past winter remains below average in annual precipitation – not helpful for trees recovering from previous drought stress. Consistently it has been found that below-average precipitation for two to three consecutive years are good predictors for the likelihood of bark beetle activity (Felix et al. 1971; Guarin and Taylor 2005, Oblinger et al. 2011) and that increased climatic water deficit correlates to levels of expected mortality (Priesler et al. 2017, Young et al 2017). Preparation for drier times are best conducted when trees are vigorous and easily recover from sudden changes in stand conditions. Prevention strategies that are integrated with fuel reduction and ecosystem restoration contribute to overall forest health and long-term sustainability.
Projects that alter the landscape are more effective as heterogeneity of sizes and age classes keep bark beetle continually searching for suitable hosts (Fettig et al 2007). Risk Map modeling for this project area show that risk is fairly high in the mixed-conifer elevations, while lower in red fir most likely due to clumpy nature of red fir. Below are general discussions of treatment activities proposed for General Sherman (*Draft* EIS 2018):

Thinning – Density reduction that increases spacing between residual trees and opens stands to greater airflow and light are much less attractive to infestation by damaging agents. Stand density indexes that target around 230 for mixed conifer and red fir (Oliver and Uzoh 1997) stand at the threshold for "eminent bark beetles mortality", and those at 365 SDI suffer severe losses.

Plantations were visited during the winter field trip, but did not have any notable insect or disease activity occurring. The plantation was pure Jeffrey pine which is often not aggressively attacked by beetles on the western side of the Sierras. Even pine engravers are not quick to attack Jeffrey pine unless green slash is generated nearby in which they could infest. However, thinning these stands to reduce growth competition would be prudent. Mature ponderosa pine plantations were especially targeted in the Sierras during the most recent drought, and should be thinned promptly in order to prevent further attack.

Thinning in red fir forests which often have root disease or heavy dwarf mistletoe infections are more selective and prescriptive than other forest types. Smaller groups or selective tree removal may be necessary to reduce current and future DM infections. Oliver and Uzoh (1997) noted that density is the primary driver or mortality in true fir stands rather than bark beetles, that a maximum SDI is much higher. However, presence of root disease or dwarf mistletoes cause additional stress that is often exacerbated during times of drought predisposing them to insect attack (Mortenson 2015, Kolb et al 2015). See below for additional information.

Prescribed Fire – reintroducing fire in the landscape is vital to restoration efforts and aligning forests within natural fire return intervals. However, long residence times or high intensity can indirectly affect tree cambium making them susceptible to bark beetles or other damage agents. Proper timing and precaution particularly during dry years should also be considered for potential bark beetle infestation. Fuel planners should monitor nearby insect activity using ADS or ground surveys pre-burn. Additional mortality above acceptable levels may occur if neighboring populations are currently active or building. It is suggested to monitor post-burn trees to look for signs of subsequent insect activity.

Pesticide use – Reduction or removal of brush using pesticides is encouraged to promote tree release and reduce ladder fuels. Pesticide use for tree protection is only recommended for high-value trees in administrative or recreation sites. FHP encourages herbicides for root disease prevention. See below for sugar pines.

Sugar Pines

White Pine Blister Rust (WPBR), *Cronartiun ribicola,* is the most serious threat to the retention of white pines in the Sierra Nevada. This non-native fungus is highly virulent on all 5-needled pines, it poses the most serious risk for continued health of sugar and western white pine in the project. USDA FS has established a breeding program to provide the forests with seed from selected sugar pine mother trees that have proven to have major genes for rust resistance. It is essential that select trees not be cut and maintained squirrel-proofed. Identified resistant seed trees have been tagged and fitted with squirrel proofing bands. These bands prevent squirrels from climbing the main bole to reach cones. As the forest ages, crowns of adjacent trees can intermingle with sugar pine crowns and thus squirrels can traverse between trees to gain access to sugar pine cones. Thus, to assist in the restoration of this species it is essential that all known rust resistant gene bearing tree within this project be released. Recommendations for mature sugar pine are release and protect if possible. Removing understory vegetation or nearby trees can help release sugar pines to improve vigor and growth. Circular removal of surrounding vegetation at least 20 feet from crown dripline is a management alternative commonly implement based on regional guidelines for 5-needled pines. Additionally it is imperative that all stumps surrounding the resistant tree treated with borate-compounds for prevention of the spread of *Heterobasidion* root disease. Protection of legacy trees from squirrel predation and *Heterobasidion sp.* root disease prevention need to complement each other to be effective.

While the recent bark beetle outbreak appears to have subsided with return of average precipitation, mountain pine beetle activity in sugar pines has been largely under-reported for the past decade due most likely due to their scattered nature and low abundance. Ground surveys have observed decline of legacy-sized sugar pines in the southern Sierras due to attacks by bark beetles rather than severe infection of invasive white pine blister rust infection (FHP, *personal observations*), similar to whitebark pine mortality in eastern Sierras (Millar et al 2012). Surveys during the recent drought in Yosemite and Sequoia-Kings Canyon National Park pine-type forests found ranges of 60-100% kill of sugar pines in mostly 8-20+ inch DBH (Battles and Axelrod, *draft results 2018*). Sugar pines are considered moderately tolerant of competition (Burns and Honkala 1990), but slowly decline if not released eventually. Dense canopies and overstocked stands contribute to mature tree decline while also hindering development of seedlings (Burns and Honkala 1990). Van Mantgem et al. (2004, 2007) noted the decline of sugar pines due to rust on long-term monitoring plots, but also climate change and increasing resource competition.

SPLaT™ is a commercially registered pesticide most effective on lodgepole and sugar pines to prevent mountain pine beetle (*Dendroctonus ponderosae*) attack. The active ingredient for this product is verbenone which as has been shown to have some deterrent properties against *Dendroctonus spp*. The formulation is a synthetic anti-aggregation compound found to discourage beetles from initiating attack on treated trees. Treatments are effective for one season only, and biodegradable; continued protection would require reapplication as needed. Treatments are fairly cost-effective in comparison to high-pressure sprays, hand application is required. Utilization of SPLAT is encouraged, especially if beetle activity in neighboring areas have been relatively high or drought conditions return by time of project implementation.

Red Fir Dwarf Mistletoe

Arceuthobium abietinum dwarf mistletoe (DM) is a native damage agent and prefers true firs (Red Fir: *f. sp. magnificae*; White fir: *f. sp. concoloris*) as hosts. Dwarf mistletoe itself is an obligate parasitic plant that relies on hosts for water and resources (Filip et al. 2000). Dwarf mistletoe is widespread in true fir forests in the Sierra Nevada, with an average of 25% of white fir typically infected in old-growth stands (Smith et al 2005, Maloney and Rizzo 2002). Infection levels vary significantly between sites, but has been found to individually intensify due to their dense canopy structure to intercept within and surrounding mistletoe seeds (Maloney and Rizzo 2002). While DM are native, high rates of infection do suppress vigor of host trees (Filip et al 2000), thus making them further susceptible to mortality when CA

experiences drought (Guarin and Taylor 2005, Mortensen et al 2015). In the southern Sierras, DM and other associated damage agents in firs have been observed becoming more severe and prolific in areas where fire regimes have been delayed, suggesting that this condition may be moving out of historical range of variation (Meyer 2013) probably contributing to higher rates of mortality (Mortensen et al 2015). Fir engraver (*Scolytus ventralis)* is more likely to attack weakened trees than those with lower levels of infection regardless of tree size. Past mortality surveys of the Eldorado and Stanislaus National Forests recorded during 1973-1978, found that nearly a quarter of ponderosa, Jeffrey, and firs were heavily infested with DM, and nearly all dead trees were attacked by insects (Scharpf and Parmeter 1978). High DMR-bark beetle association was also strongly noted in several other Forests across the West (Scharpf and Parmeter 1978, Goheen and Hansen 1993). An associated canker (*Cytospora sp.)* utilizes wounds created by DM or bark beetles to infect the inner bark, additional stress that eventually causes branch die-back (Wood 2003). Often no management is recommended in diverse stands where hosts are buffered among non-host trees and infection rates low, but should be treated where infection is notably affecting growth and regeneration.

The main objective of DM management is to reduce current infestation to levels that do not severely impact tree growth and development. Overstory trees with severe dwarf mistletoe infection (DMR>5) are inoculum sources for DM to spread to neighboring host trees. The spread either intensifies already infected trees or creates new infections. Intensifying infections are most concerning for understory, as the continual "rain" of DM seeds from above severely limit their ability to grow and develop normally; it is suggested that shelterwood trees should be uninfected or with DMR <3 (Filip et al 2000). Highly infected trees are also poor seed sources for natural regeneration as they too are weakened (Filip et al 2000). There is a strong inverse relationship of live crown ratios to DRM: trees with high infection grew slow, low infected trees grew faster (Filip 1984). While mature highly DM infected trees can be characteristic wildlife habitat, the long term sustainability of the stand may be compromised if those trees are unable to produce viable seed. If sanitation is implemented, residual understory should have none or little infection to keep DM low in proceeding years.

Root Disease

Heterobasidion root disease is likely to impact this project, though only one species is likely to be a major problem. *Heterobasidion occidentale* (fir or S-type) is the most ubiquitous disease of true firs in Sierra Nevada, while *H. irregulare* is uncommon and found in pines. While both of these diseases are native, neither is a significant cause of mortality alone but rather part of a natural disturbance complex (Goheen and Hansen 1993). While root diseases work slowly to kill their hosts, their presence can be a contributor to physiological stress that increases susceptibility to other damage agents (Manion and Lachance 1992). Once established they are pervasive, spreading through various means – particularly if host density is high (Goheen and Hansen 1993). Root diseases can be insidious and difficult to detect especially since fruiting bodies (conks) are often hiding within decaying stumps. Confirmation of presence within trees and stands requires lots of destructive sampling, but symptoms of *Heterobasidion* or general root disease infection can be observed and noted. While *H. irregulare* (pine or P-type) is rarely encountered west-side of the Sierras, it can become established, and once established persist until there is a species conversion away from pine.

There is an effective treatment for mitigating associated mortality, and preventing new disease infections (Graham 1971; Smith 1970). Kleijunas (1989) summarized the existing literature on borax effectiveness in the eastside pine type. Mitigation methods are described in the R05 Heterobasidion root disease web page at: http://www.fs.usda.gov/detail/r5/forest-grasslandhealth/insects-diseases/?cid=stelprdb5329386. Regional Policy is described in the FSH 3409.11 at https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5329399.pdf There are additional links to commonly asked questions about treatment. FHP is available to provide training in the application of these preventative measures.

Summary

Removal of trees with DMR>5 is suggested where inoculum in the upper story is an issue for the understory, but often no treatment is recommended. However, sites may be decadent or in need of assisted disturbance to realign processes within ecosystems to more historic patterns, the introduction of prescribed wildfire or tree removal will greatly help. Prescribed fire can sanitize areas with high DM infections and reduce potential for long residual burn that can damage cambium while building resilience in remaining trees (Hood et al. 2015). Thinning prescriptions that reduce overall stand density are always beneficial to reducing inter-tree competition, but the treatment should be adequate enough to significantly alter the microsite to reduce likelihood of bark beetle infestation (Fettig et al. 2007).

With climate change having the greatest effect on trees regardless of endogenous causes (van Mantgem et al 2009), this project is supported to enhance residual forests and ecosystem, maintain their vigor and resilience in the face of significantly changing environments. A nearly 66% range reduction of Red fir is predicted in the Sierras in the next 100 years due to climate change impacts (Meyer 2013) thus project treatments to improve health, regeneration, and develop resilience are all the more urgent. Restoring landscapes to resilient and resistant conditions is necessary to protect natural resources, public, and neighboring private lands while still allowing natural processes to occur with the flexibility to adapt.

If there are further questions regarding General Sherman Project or concerns regarding this report, please do not hesitate to contact us.

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Appendix A. 2017 Aerial Detection Mortality Survey (light red polygons) within General Sherman project area, Placerville Ranger District (black outline is project boundaries). *Note: more than 60% of project was detected with some level of mortality in 2017.*